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(71) Applicant : **TOSHIBA LIGHTING & TECHNOLOGY CORPORATION**
3-1, Higashishinagawa 4-Chome
Shinagawa-ku, Tokyo (JP)

(72) Inventor : **Sugimoto, Takahiro**
2031-1, Izumi-cho,
Izumi-ku
Yokohama-shi, Kanagawa-ken (JP)
Inventor : **Ueda, Akihiro**
2-10-2-201, Tsurumichuo,
Tsurumi-ku
Yokohama-shi, Kanagawa-ken (JP)
Inventor : **Higashi, Tadatoshi**
6-33-2, Baba,
Tsurumi-ku
Yokohama-shi, Kanagawa-ken (JP)

(74) Representative : **O'Connell, David Christopher et al**
HASELTINE LAKE & CO.
Hazlitt House
28 Southampton Buildings
Chancery Lane
London WC2A 1AT (GB)

(54) **Metal halide discharge lamp suitable for an optical light source.**

(57) A metal halide discharge lamp operated from a D.C. power source, which is suitable for an optical light source, has a quartz arc tube. Anode and cathode electrodes are disposed in the arc tube. A gap length between electrodes is so short that the metal halide discharge lamp is capable to function as a point light source. The arc tube contains an inert gas, mercury and metal halide additives including metal bromine. By utilizing the catephoresis effects, the transformation of silica (SiO_2) of the arc tube to be the cystbalite or the formation of an opaque substance on the arc tube is prevented. Atomic percent of bromine to halogen contained in the arc tube is about 60% to 90% and a wall load developed in the arc tube is substantially greater than 40 W/cm^2.

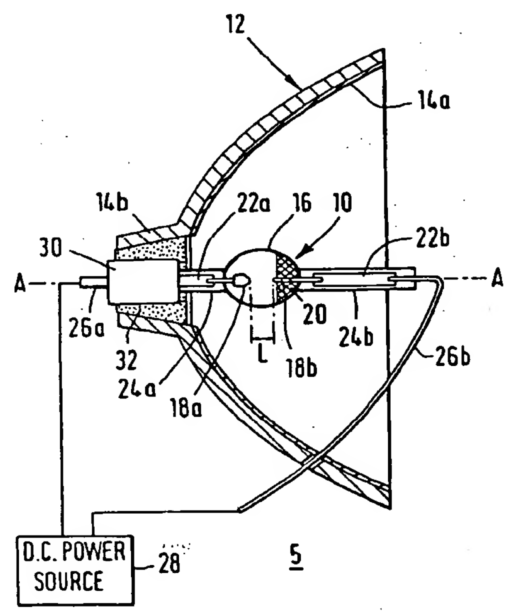

FIG.1.

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Jouve, 18, rue Saint-Denis, 75001 PARIS

The present invention relates to a discharge lamp specially suited for a forward lighting application of an optical apparatus and more particularly, to a m tal halide discharge lamp operating from a D.C. power source suited for an optical light source of a projector device such as a projection color display apparatus.

Recently, it has been proposed to utilize a metal halide discharge lamp as a light source for a projection color display apparatus. U.S. patent No. 5,135,300 discloses a projection color display apparatus in which a metal halide lamp as a white light source is assembled. The light source uses a parabolic r flecting mirror having a concave surface so as to converge the light flux emitted from the light source with efficiency and to obtain parallel rays. The light source is made as close to a point source as possible and it is mounted within the reflecting mirror so as to coincide the focal point of the reflecting mirror with the center of the light output from the light source. The metal halide discharge lamp has a pair of electrodes, and the gap length between the electrodes is shorter than conventional metal halide discharge lamps used for general illumination purpose such as streetlights and floodlights The discharge lamp disclosed in the patent is called a short arc metal halide discharge lamp.

As for metal halide additives filled in an arc tube of a metal halide discharge lamp, dysprosium iodide, indium iodide, thallium iodide and cesium iodide are known to efficiently produce red, green and blue components of the light. In operation of such a metal iodide discharge lamp, all of the mercury is vaporized, resulting in a high-pressure, wall-stabilized arc in a gas consisting principally of mercury vapor at several atomospheres pressure. The iodides also evaporate from the arc tube walls, the iodide molecules diffusing into the high-temperature arc column, where they dissociate. The metal atoms are ionized and excited and give off their own characteristic spectral lines. As metal atoms diffuse back to the walls, they encounter iodide atoms in the cooler gas near the walls and recombine to reform the iodide molecules.

When a short arc metal halide discharge lamp is operated, the power consumption of the arc column or the wall load of the lamp defines the power consumed by the arc column per inside wall surfaces of the arc tube (W/cm^2) becomes extremely high to raise the wall temperature of the arc tube almost to its melting point, and metal ions of the additives, such as metal ions of rare-earth metals or metal ions of alkali metals react with silica (SiO_2) of the arc tube considerably to lose the transparency of the arc tube. It is assumed that silica at the high temperature tube walls exposed by the metal ions tends to be transformed in its crystalline structure,to a crystbalite known to be an opaque substance,easily. Such transformation firstly occurs at the hottest wall areas after 100 hours operation. Loss of the transparency spreads over the other wall areas and the whole wall areas are finally covered with the opaque substance. After 1000 hour-operation, the inside walls of the arc tube appear as if white refractory materials are deposited thereon, and the transparency of the arc tube is almost lost. A metal halide discharge lamp having such a non-transparent arc tube is no longer used for a point light source because the arc tube diffuses the light emitted from the arc column.

In a metal halide lamp operated from a direct current (D.C.) power source, it typically experiences the effects of catephoresis which cause the halides of the metal halide discharge lamp to be moved or swept into the end regions of the lamp so as not to contribute to providing the desired illumination of such lamp. Conventionally, it has been tried to reduce the detrimental effects of catephoresis as disclosed in U.S.Patent 4,935,668.

Embodiments of the present invention provide a metal halide discharge lamp having a quartz arc tube in which a pair of electrodes is disposed. The electrodes, i.e. anode and cathode electrodes are separated from each other by a predetermined distance. A D.C. potential is applied between the anode and the cathode from an external power source and an arc discharge is developed between the electrodes. The arc tube contains an inert gas, mercury and metal halide additives including metal bromide. Atomic percent of bromine to halogen contained in the arc tube is about 60% to 90% and a wall load developed in the arc tube is substantially greater than 40 W/cm^2

The accompanying drawings, which consititute a part of the specification, illustrate a presently preferred embodiment of the invention.

Fig. 1 is a side view generally illustrating an optical light source having a metal halide discharge lamp disposed inside a reflector, in accordance with the present invention,

Fig. 2 is a graph showing lumen maintenance ratio of the metal halide discharge lamps as a function of operation hours and atomic percent of bromine to halogen contained in an arc tube of the metal halide lamp; and

Fig. 3 is a diagrammatic view of a LCD color display device in which the optical light source is assembled.

Fig. 1 is a side view generally illustrating an optical light source 5 having a metal halide discharge lamp 10 according to the present invention. Metal halide lamp 10 is disposed inside a reflector 12. Reflector 12 has a light reflecting section 14a provided thereon so as to converge the light flux from metal halide discharge lamp 10 and to project parallel rays. Reflector 12 has a recessed section 14b for fixing metal halid discharge lamp 10 therein. Reflector 12 is made of glass, how ver it may be made of metals. Light reflecting s ction 14a is formed with optical interference films comprising alternating lay rs of tita-

nium and silica for high temperature use.

An arc tube 16 of metal halide discharge lamp 10 is made of quartz glass and formed substantially in spheroidal shape. An anode electrode 18a and a cathode electrode 18b are opposedly disposed at each end of arc tube 16 Electrodes 18a, 18b are separated from each other by a predetermined distance (L). In order to obtain a point light source, the distance or the gap length between electrodes 18a, 18b is less than 15mm. The electrodes 18a, 18b are rod-like members made of tungsten containing thorium oxide, also known as thoriated tungsten. Anode electrode 18a has a larger diameter than cathode electrode 18b for a desirably greater heat dissipation therefrom when operated with a direct current power source, although electrodes of the same size are generally selected for lamp operation with an alternating current power source.

Metal halide discharge lamp 10 is so oriented in a horizontal manner along an optical axis A-A of reflector 12 that the electrodes 18a, 18b are placed on axis A-A. Reflector 12 has a predetermined focal point along axis A-A and a light emitting portion developed by the discharge between electrodes 18a, 18b is positioned at the forcal point. An infrared alumina coating 20, which substantially surrounds cathode electrode 18b,is formed inside arc tube 16. Infrared coating 20 also serves to be a light-reflective shield. Electrodes 18a, 18b are respectively welded to foil members 22a, 22b made of molybdenum and sealed in neck portions 24a, 24b of arc tube 18. Inlead wires 26a, 26b, which are capable of being connected to an external D.C. power source 28 are electrically connected to foil members 22a, 22b.

A base member 30 which holds neck portion 24a and secures the electrical contact between lead wire 26a and foil member 22a, is disposed in recessed section 14b of reflector 12. Recessed section 14b is filled with adhesive materials 32 so that base member 30 is fixed therein.

In the first embodiment of metal halide discharge lamp 10 for 250 W (Wall load 50 W/cm^2), spheroidal arc tube 16 has a wall thickness of 1.4 mm and a volume of about 0.9 cm^3. The major axis and the minor axis of spheroidal arc tube 16 are 15mm and 10.5mm, respectively. The gap length between anode 18a and cathode 18b is about 6mm. Anode 18a has a diameter of 1.6mm while cathode 18b has a diameter of 0.6mm. Metal halide discharge lamp 10 contains in its arc tube 16 mercury in an amount of about 20mg, argon gas at 40kPa (300 Torr) at room temperature and metal halide additives shown in Table 1. Atomic percent of bromine to halogen in arc tube 16 is about 85%, i.e. bromine atoms make up about 85% of the halogen atoms. A metal halide discharge lamp 10 thus constructed attains a luminous efficacy of 80 lm/W and a color temperature of 7500K.

TABLE 1

Metal halide additiv s	
Dysprosium bromide ($DyBr_3$)	1.0 mg
Dysprosium iodide (DyI_3)	0.37 mg
Cesium iodide (CsI)	0.125 mg
Tin bromide ($SnBr_2$)	0.6 mg
Indium bromide (InBr)	0.22 mg
Thallium bromide (TlBr)	0.4 mg

In a second embodiment of a metal halide discharge lamp 10 in accordance with the invention for 180 W (Wall load 50 W/cm^2), spheroidal arc tube 16 has a wall thickness of 15mm and a volume of about 0.5 cm^3. The major axis and the minor axis of spheroidal arc tube 16 are 10mm and 9.0mm, respectively. The distance between anode 18a and cathode 18b is about 5mm. Anode 18a has a diameter of 1.2mm while cathode 18b has a diameter of 0.5mm. Metal halide discharge lamp 10 contains in its arc tube 16 mercury in an amount of about 13mg, argon gas at 40kPa (300 Torr) at room temperature and metal halide additives shown in Table 2. Atomic percent of bromine to halogen in arc tube 16 is about 75%. A metal halide discharge lamp 10 thus constructed attains a luminous efficacy of 80 lm/W.

TABLE 2

Metal halide additives	
Dysprosium bromide ($DyBr_3$)	0.5 mg
Dysprosium iodide (DyI_3)	0.375 mg
Cesium iodide (CsI)	0.125 mg
Tin bromide ($SnBr_2$)	0.2 mg
Indium bromide (InBr)	0.22 mg
Thallium bromide (TlBr)	0.4 mg

In both illustrated embodiments of the invention, 100% of the halides, other than bromides, are iodides, and this is preferred. However, lamps with other halides present, having iodides making up more than 90% of the halides other than bromides, also have high intensities of light emission.

In the embodiments or examples of the metal halide discharge lamp according to the invention, the catephoresis effect is turned into an advantage. Ionized metals of metal halides in arc tube 16 are attracted towards cathode 18b where negative potential is applied from D.C. source 28 and they are retained

near cathode 18b. It is presumed that the opportunity for the ionized metals to attack the arc tube walls and r act with silca contained in th arc tube, particularly the upper center arc tube wall or the arc tube walls facing to anode electrode 18a is reduced. The ionized metals are thus kept away from high temperature regions of arc tube 16. This prevents transformation of the silica to a crystbalite or formation of an opaque substance on arc tube 16. Transparency of arc tube 16 is thus maintained during the life time of metal halide discharge lamp 10. Even if the transformation causes the opaque substance to form on the arc tube walls facing cathode electrode 18b due to the attracted metal ions, the rest of the walls ofarc tube 16 are kept clear to transmit the light emitted by the discharge to reflector 12 therethrough and the light emitted from near cathode 20b is reflected back to reflector 12 through the clear arc tube wall with aid of infrared coating 20. An excellent point light source having a high luminous efficacy is obtained.

Fig. 2 is a graph showing lumen maintenance ratio of various metal halide discharge lamps as a function of atomoic percent of bromide to halogen contained in the arc tube. To attain more than 70 % lumen mentenance after 2000 hours operation, atomic percent of bromide to halogen is preferably selected between 60 % and 90 %. If atomic percent of bromide to halogen is more than 90 %, the light emission itself is decreased considerably and the color rendition becomes poor.

In the metal halide discharge lamp according to the present invention, a halogen cycle is performed as in a conventional metal halide discharge lamp and bromide functions as means for transporting tungsten back to anode electrode 20a. Bromide is more active than iodide, however erosion of anode electrode 20a caused thereby is not detrimental if the atomic percent of bromide to halogen is within a prescribed range because the diameter of anode electrode 20a is larger than electrodes of a conventional metal halide discharge lamp operated from an A.C. power source as described above.

Metal halide discharge lamp 10 is utilized for a projection color display apparatus as a point light source. Fig. 3 is a diagrammatic view of a LCD color display device 50 in which optical light source 5 is assembled. Metal halide discharge lamp 10 in optical light source 5 emits a white light flux 51. A dichroic mirror 52, which has a wavelength selectivity for reflecting a blue light flux 53B and transmitting a mixed light flux 54 of red and green light fluxes, is provided in the path for light flux 51. In the path for blue light flux 53B, a reflecting mirror 55 is provided which reflects the blue light flux 53B as a light flux 56B. In the path for the light flux 54, a dichroic mirror 57 is provided which has a wavelength selectivity for reflecting a red light flux 58R and transmitting a green light flux 59G. In the paths for the light fluxes 568, 58R and 59G, transmission light valves 60B, 60R and 60G are respectively provided. Each of light valves 608, 60R and 60G is constituted by a liquid crystal device and they are driven or modulat d in accordance with TV signals or th like. Modulated light fluxes 568 and 58R from light valves 60B and 60R are respectively directed to a dichroic mirror 61. Dichroic mirror 61 transmits modulated light flux 568 and reflects modulated light flux 58R, thereby forming a light flux 62 which is a mixture of modulated light fluxes 56B and 58R. A dichroic mirror 63 transmits light flux 62 and reflects modulated light flux 59G, thereby forming a light flux 64 which is a mixture of light fluxes 59G and 62. A mirror 65 is provided to reflect modulated light flux 59G to mirror 63. Light flux 64 is projected to a screen 66 through a projection lens 68.

Metal halide dishcarge lamp according to the invention has a high luminous efficacy and long life, but it eliminates color shading occured at center and peripheral areas of images projected on a screen if utilized for a light source of a color display device.

While there have been shown and described what are at present considered the preferred embodiments of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the scope of the invention as defined by the appended claims.

Claims

1. Metal halide discharge lamp suitable for an optical light source comprising:

    a quartz arc tube having a pair of electrodes disposed therein, said electrodes comprising anode and cathode electrodes and separated from each other by a predetermined distance;

    said arc tube containing an inert gas, mercury and metal halides including metal bromide, wherein the atomic percent of bromine to halogen contained in said arc tube is about 60% to 90% and a wall load developed in said arc tube is substantially greater than 40 W/cm^2; and

    means for providing a D.C. potential between said anode and cathode from an external power source therethrough.

2. Metal halide discharge lamp according to claim 1, wherein said metal halides include a halide of at least one metal selected from the group consisting of dysprosium, indium, thallium, neodymium, tin and cesium.

3. Metal halid discharge lamp according to claim 1, wherein said metal bromide f said metal halide fill includes dysprosium bromide and tin bromid .

4. Metal halide discharge lamp according to claim 1, wherein said metal halide fill further including metal iodine and atomic percent of iodide to halogen other than bromine contained in said arc tube is more than 90%.

5. Metal halide discharge lamp according to claim 4, wherein said metal halide fill includes at least one metal selected from the group consisting of dysprosium, indium, thallium, neodymium, tin and cesium.

6. Metal halide discharge lamp according to claim 4, wherein said metal bromine of said metal halide fill includes at least one metal bromine selected from the group consisting of dysprosium bromine, tin bromine, indium bromine and thallium bromine and said metal iodine of said metal halide fill includes at least one metal iodine selected from the group consisting of dysprosium iodine, cesium iodine and neodymium iodine.

7. An optical light source comprising:
metal halide discharge lamp including a quartz arc tube, said quartz arc tube having a pair of electrodes disposed therein and separated from each other by a predetermined distance,
said electrodes comprising of anode and cathode electrodes, wherein a wall load developed in said arc tube is substantially greater than 40 W/cm^{2}and means for providing a D.C. potential between said anode and cathode electrodes from an external power source therethrough,
said arc tube containing an inert gas, mercury and a metal halide fill including metal bromine, wherein atomic percent of bromine to halogen contained in said arc tube is about 60% to 90%; and
a reflector having a predetermined focal length and means capable of being connected to the external power source, wherein said metal halide discharge lamp is positioned whithin said reflector so as to be approximately disposed near said focal length of said reflector.

8. An optical light source according to claim 7, wherein said metal halide discharge lamp is horizontally positioned within said reflector so that said anode and cathode electrodes are substantially coincide with a horizontal axis of said reflector.

9. An optical light source according to claim 8, wherein the distance between said anode and cathode electrodes is selected to be less than 15mm and said cathode electrode is substantially located near said forcal length whereby a light spot generated inside said arc tube is substantially positioned at said focal length.

10. An optical light source according to claim 8, wherein said metal halide fill includes at least one metal selected from the group consisting of dysprosium, indium, thallium, neodymium, tin and cesium.

11. An optical light source according to claim 8, wherein said metal bromine of said metal halide fill includes dysprosium bromine and tin bromine.

12. An optical light source according to claim 8, wherein said metal halide fill further includes metal iodine and atomic percent of iodide to halogen other than bromine contained in said arc tube is more than 90%.

13. An optical light source according to claim 12, wherein of said metal halide fill includes at least one metal selected from the group consisting of dysprosium, indium, thallium, neodymium, tin and cesium.

14. An optical light source according to claim 11, wherein said metal bromine of said metal halide fill includes at least one metal bromine selected from the group consisting of dysprosium bromine, tin bromine, indium bromine and thallium bromine and said metal iodine of said metal halide fill includes at least one metal iodine selected from the group consisting of dysprosium iodine, cesium iodine and neodymium iodine.

15. A color display device having a metal halide discharge lamp as an optical light source directing light including green and blue light components for projecting a color image on a screen comprising means for optically filtering the red, green and blue light components, means for modulating each of the light components with an image signal and producing modulated signals and means for optically synthesizing the modulated signals, wherein said metal halide discharge lamp includes a quartz arc tube having a pair of electrodes disposed therein, said electrodes having anode and cathode electrodes and separated from each other by a predetermined distance; said arc tube containing an inert gas, mercury and a metal halide fill including metal bromine, wherein the atomic percent of bromine to halogen contained in said arc tube is about 60% to 90% and a wall load developed in said arc tube is substantially greater than 40 W/cm^2; and means for providing a D.C. potential between said anode and cathod electrodes from an external power source therethrough.

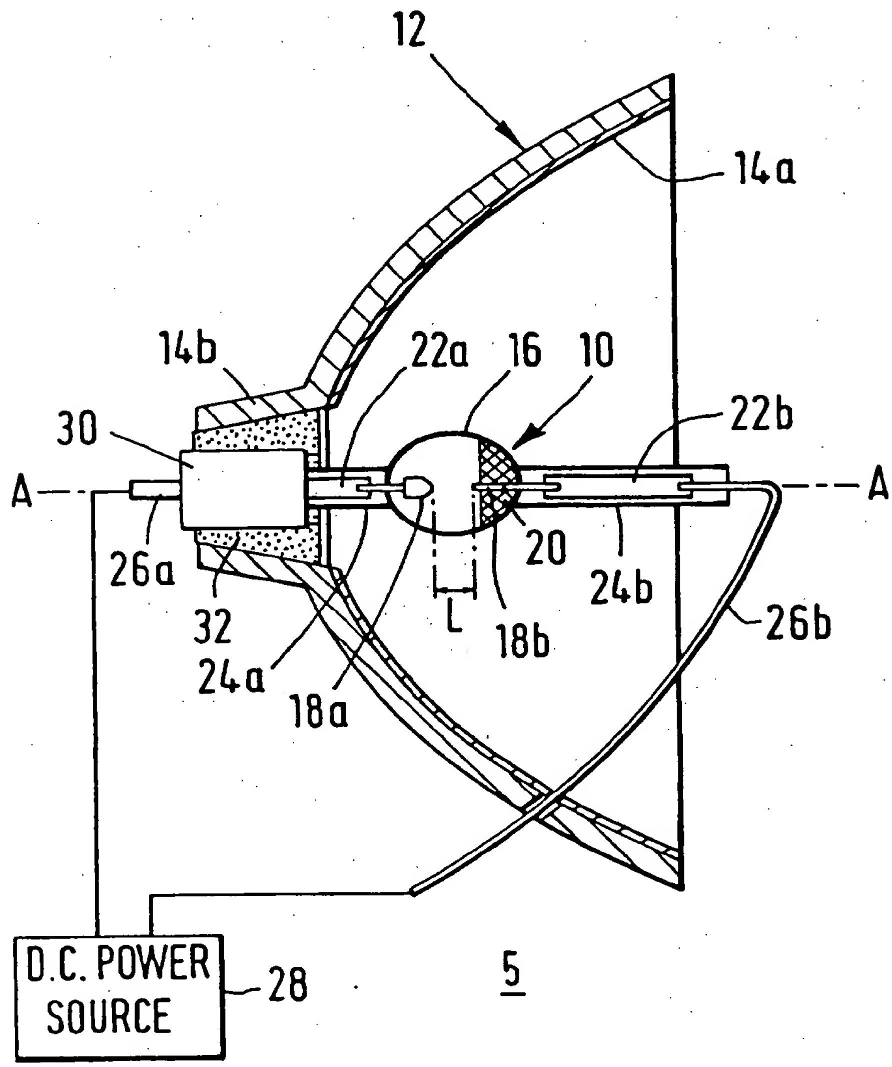
12
14a
14b
22a
16
10
30
22b
A
A
26a
32
20
24b
26b
L
18b
24a
18a
D.C. POWER SOURCE
28
5

FIG.1.

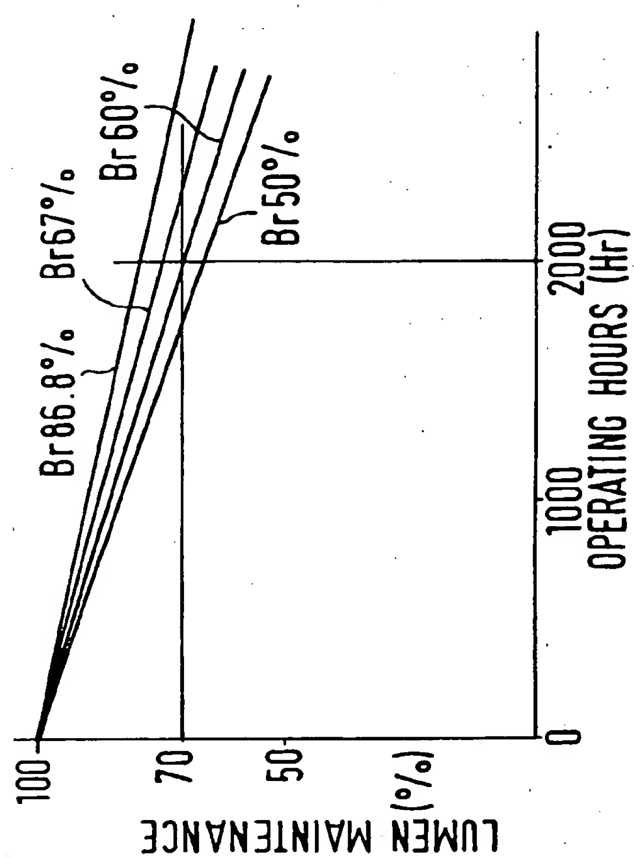
LUMEN MAINTENANCE (%)
100
70
50
0
1000
2000
OPERATING HOURS (Hr)
Br86.8%
Br67%
Br60%
Br50%

FIG.2.

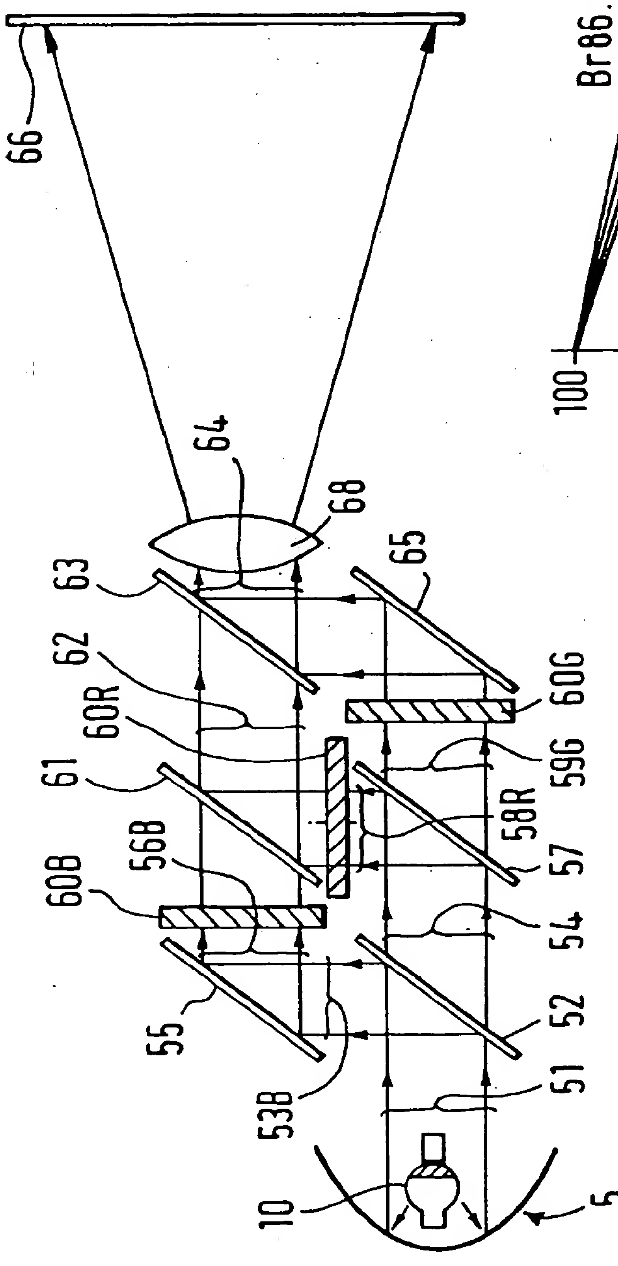
66
64
68
63
62
60R
61
60B
56B
55
53B
10
5
51
52
54
57
58R
59G
60G
65

FIG.3.